

# Status report on Cosmic Ray Tagger for 3x1x1/6x6x6, and observation of upward going particles in WA105

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LBNODEMO/WA105 bi-weekly science board meeting  
12.10.2016

<http://lbnodemo.ethz.ch:2500/3x1x1/35> :

1. feb-v3-0-1.pdf: description of FE electronics and communication
2. sbnd-crt-part1,2: technical design note for SBND CRT (90% compatible)
3. missing: 3D CAD model for 3x1x1

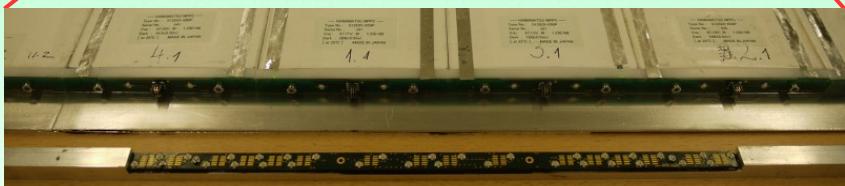
16 strips per module

Strip width: 112 mm

Strip length: 1755mm

Module size:  
1.8x1.8m

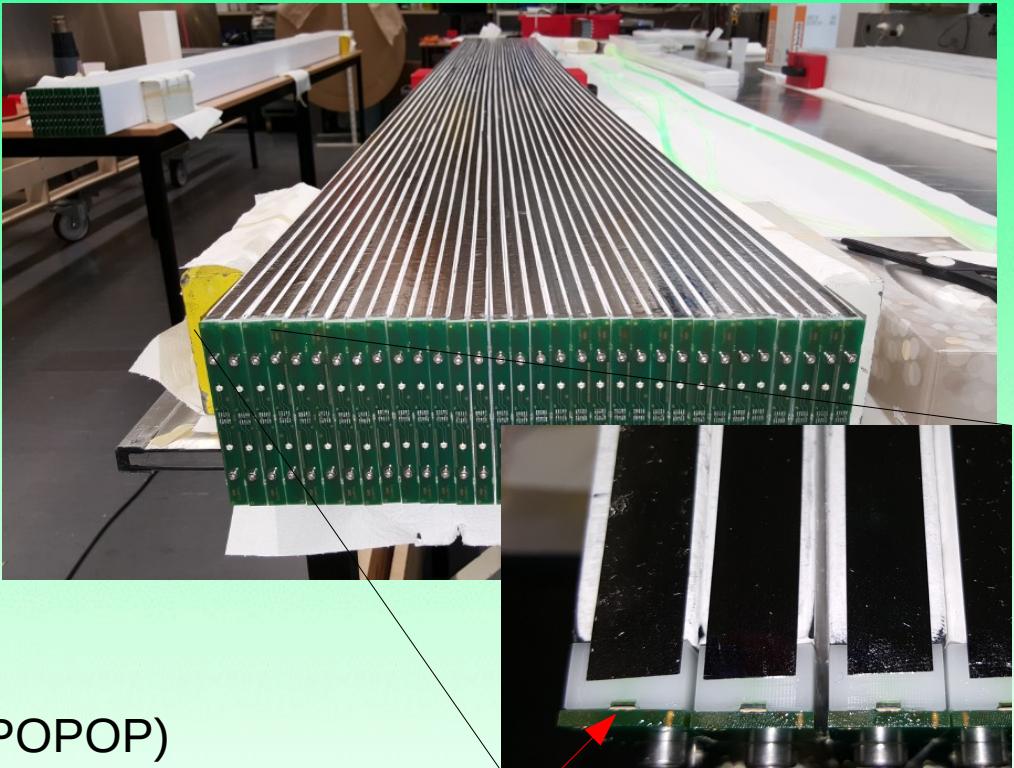
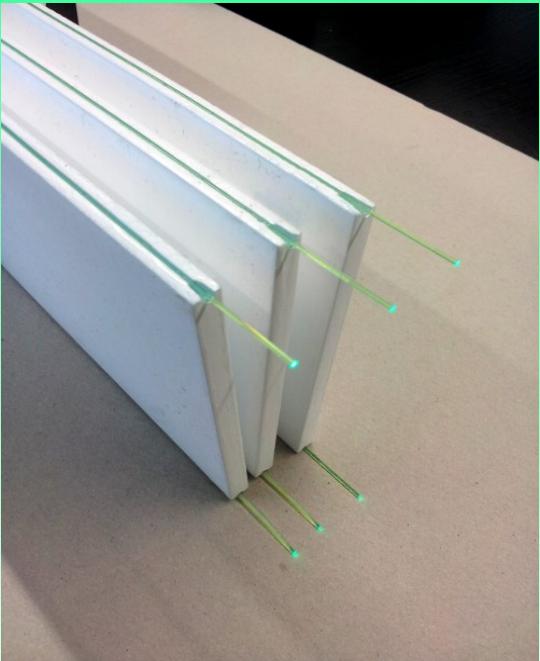
Aluminum case  
(2 mm thick)



Feed-through PCB

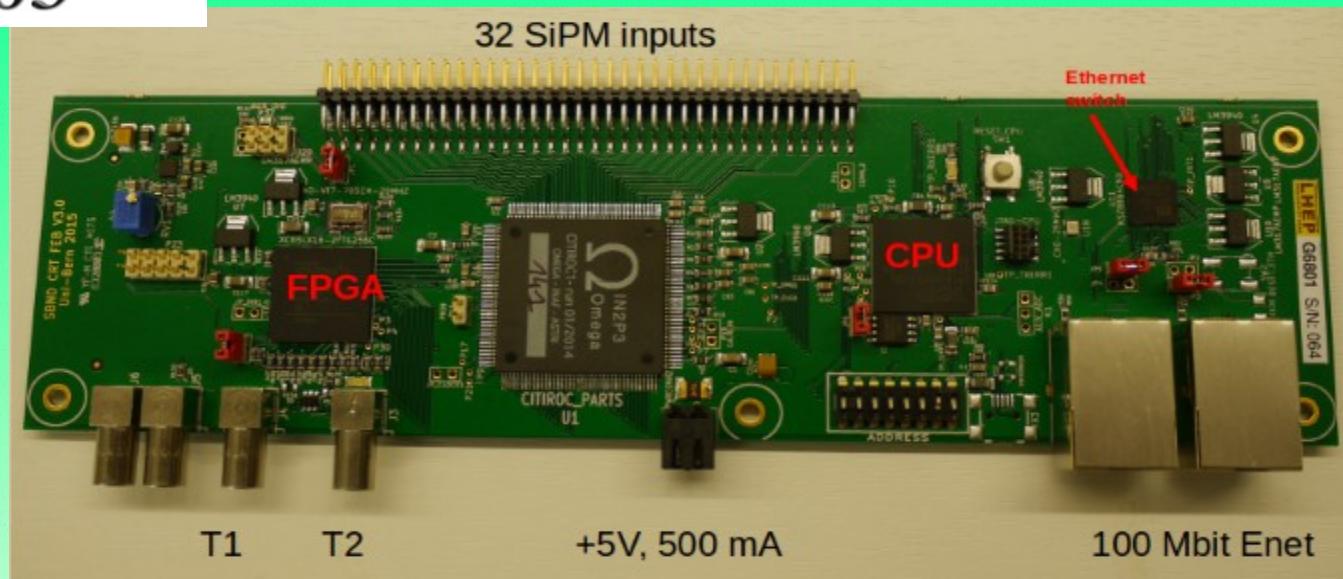


32 coax cables inside

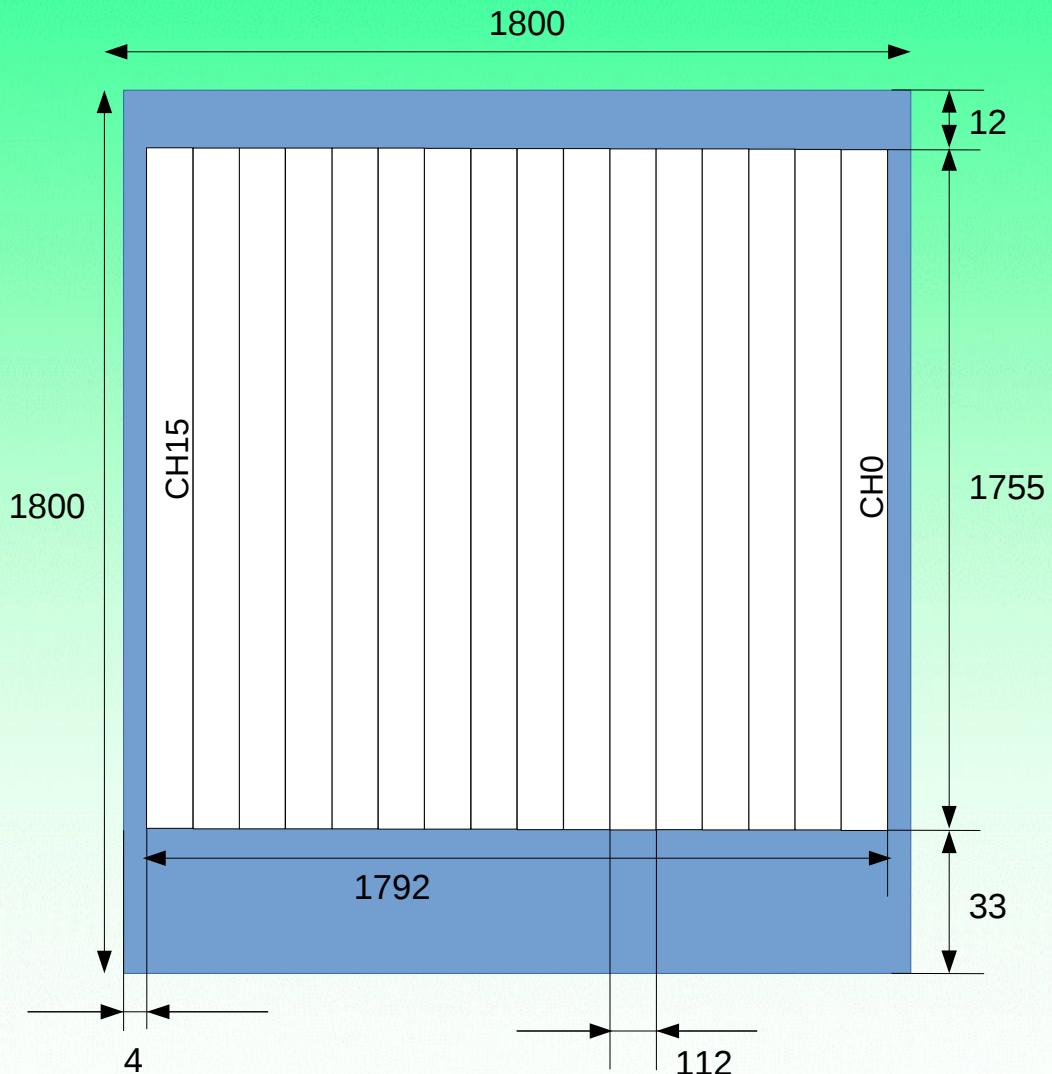


Scintillator: USMS-03 (PS+PTP+POPOP)  
Reflective surface (UNIPLAST technology)  
WLS fibers: Kuraray Y11(200)MS, 1mm diameter  
Optical glue: ESA 7250 polysiloxane compound  
SiPM: Hamamatsu S12825-050P

2 SiPMs per strip

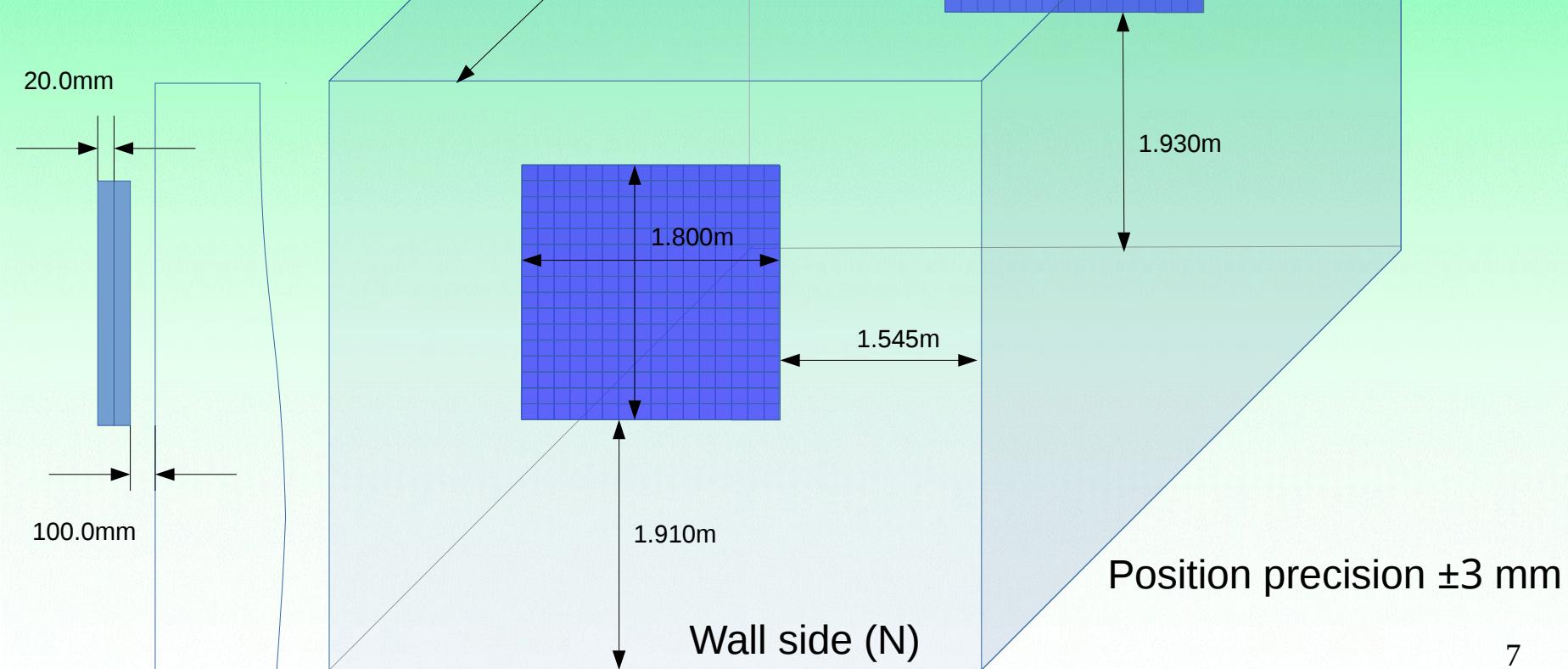


180 pieces produced, tested. (50 for uBooNE + 130 for SBND)  
20 more are ordered.

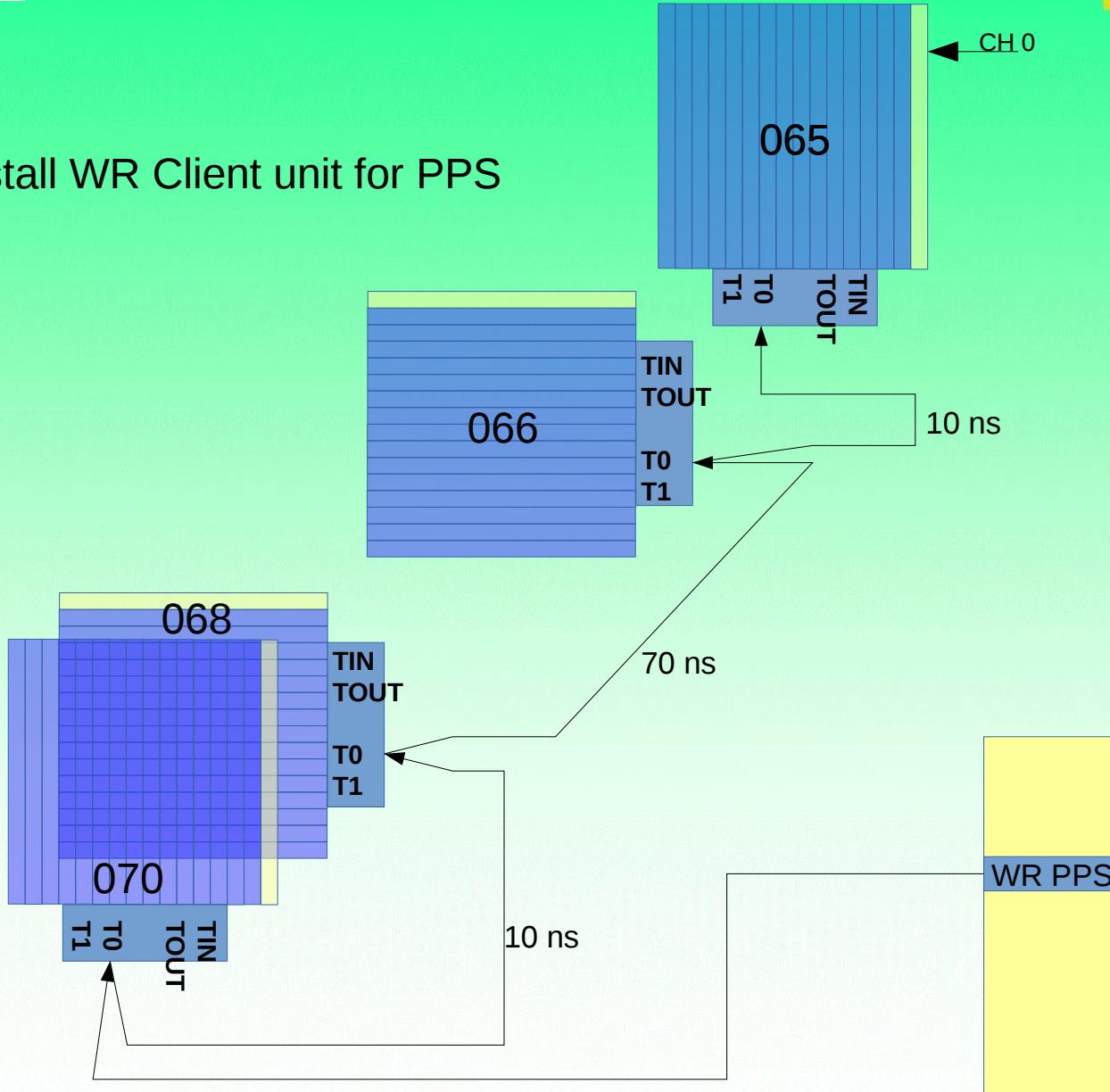




Gate side (S)



TODO: install WR Client unit for PPS



Each pair works in local X-Y coinc. mode

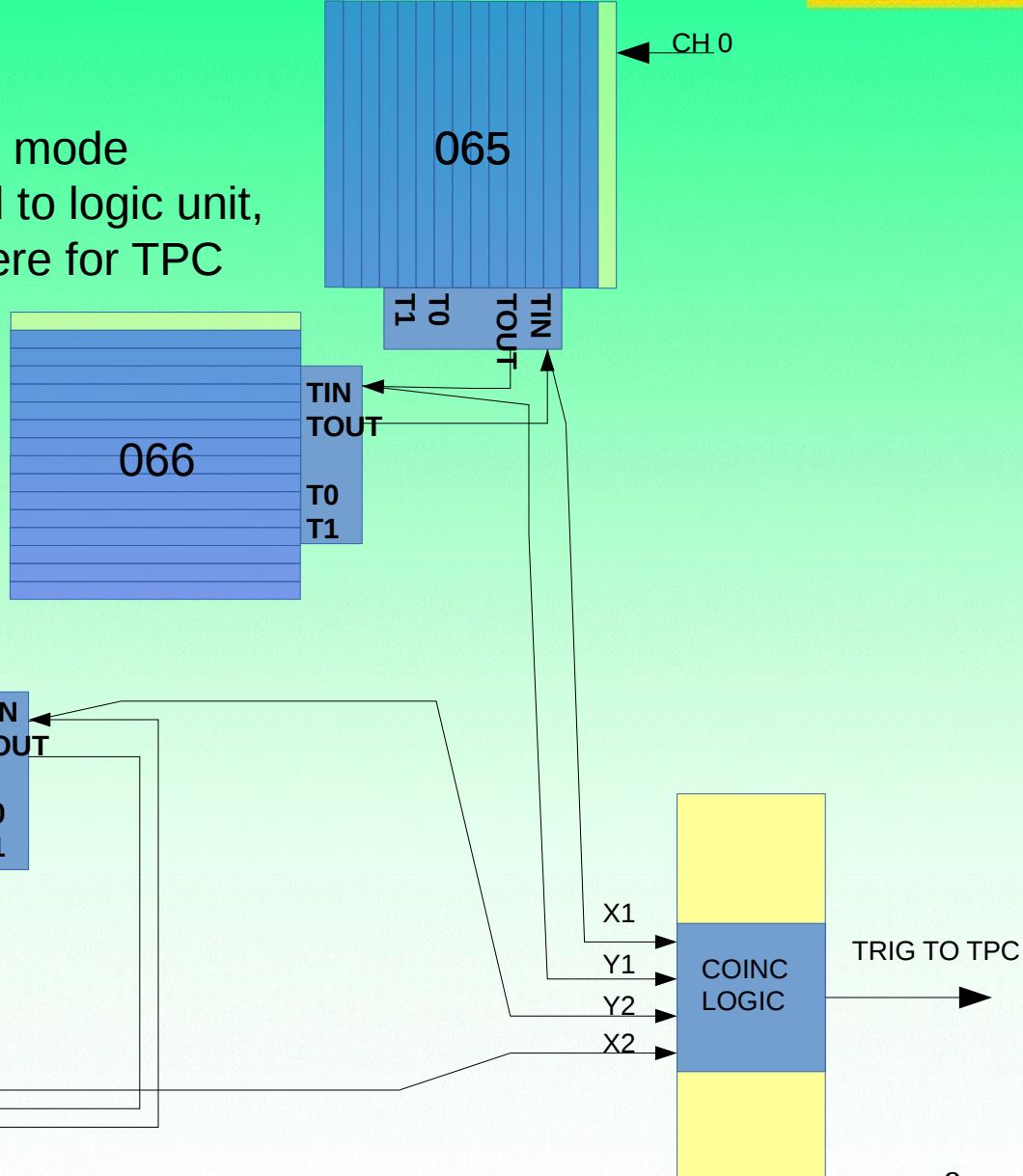
Triggers from each plane delivered to logic unit,  
any coinc. logic can be realized there for TPC

TODO:

replace TTL-NIM-TTL

check logic unit

eventually replace with Bern unit



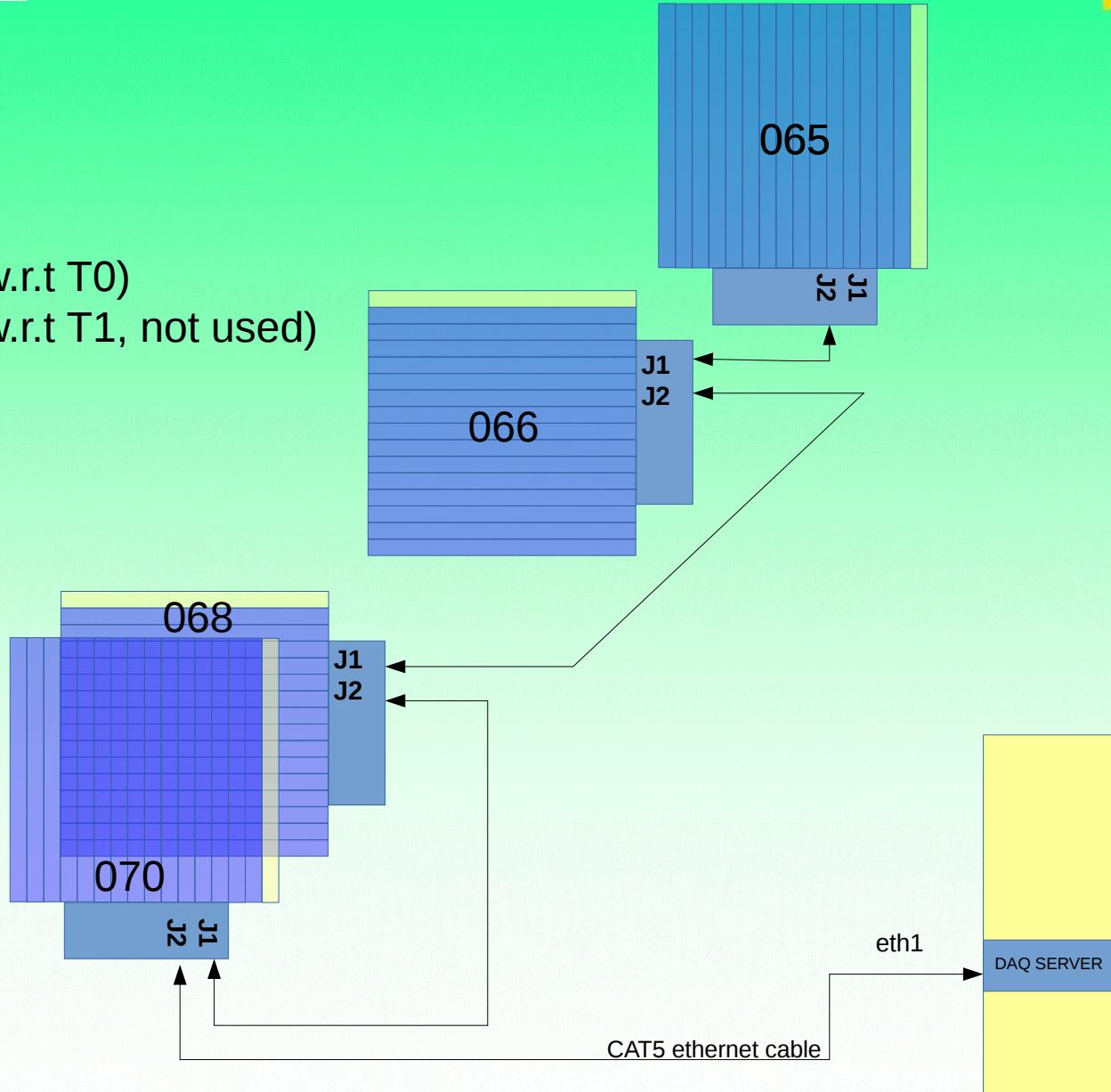
Event:

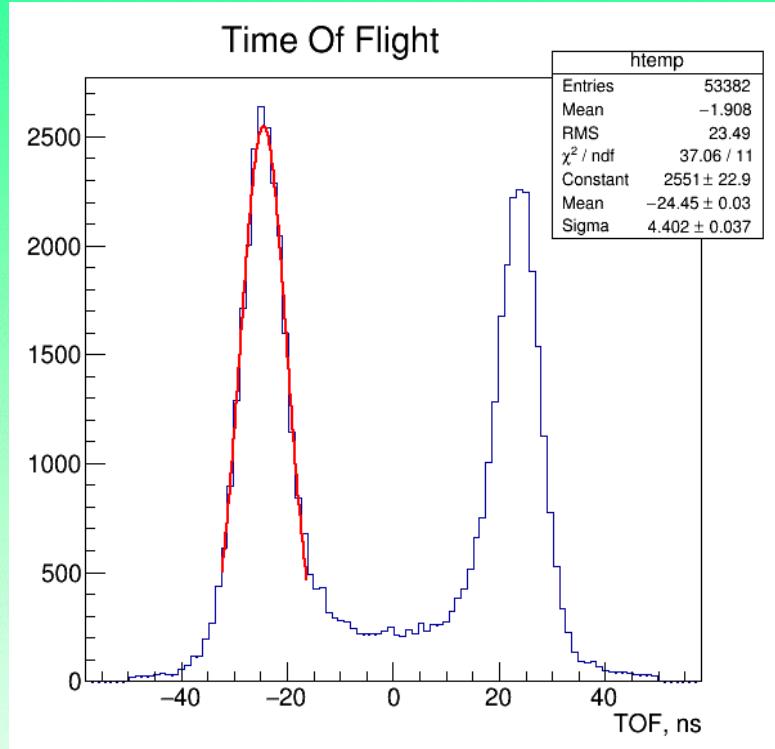
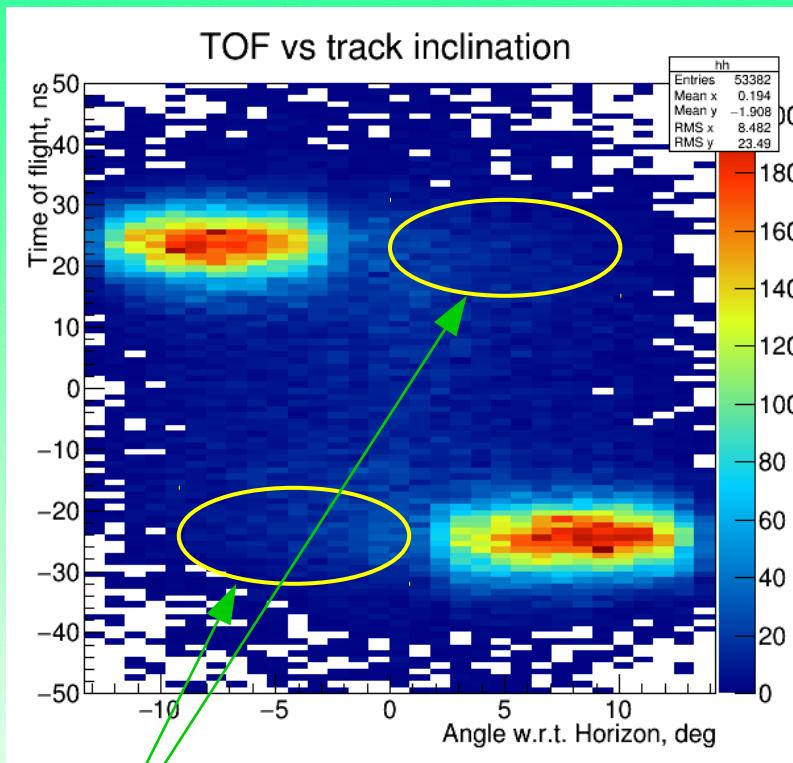
flags

ts0, ns (time w.r.t T0)

ts1, ns (time w.r.t T1, not used)

ADC[32]

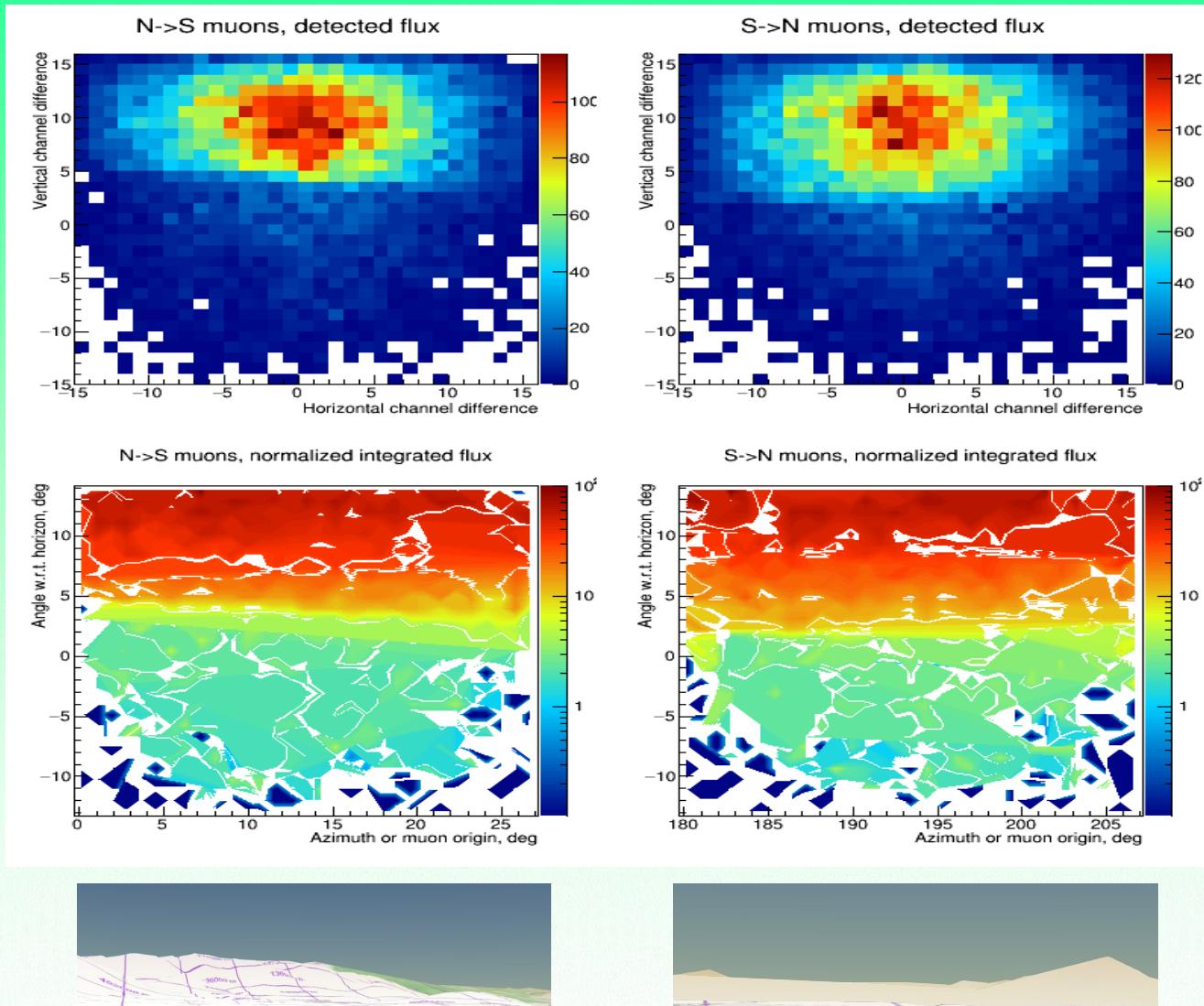




Upward-going muons(?)

TOF resolution ~4.4 ns

Detected muon flux:  
N->S direction: ~3.1 muons/min  
S->N direction: ~3.6 muons/min



- Lack of information or not very reliable measurements
- PDG review on cosmic rays says almost nothing about flux near horizon
- "Effects of upward-going cosmic muons on density radiography of volcanoes"  
K. Jourde et al., arXiv:1307.6758v1

**Question remains:**  
**Low or high energy?**  
**(Scattered or through-going?)**

- Monte Carlo simulation for background study of geophysical inspection with cosmic-ray muons,  
R. Nishiyama et al.,  
Geophys. J. Int. (2016) 206, 1039–1050

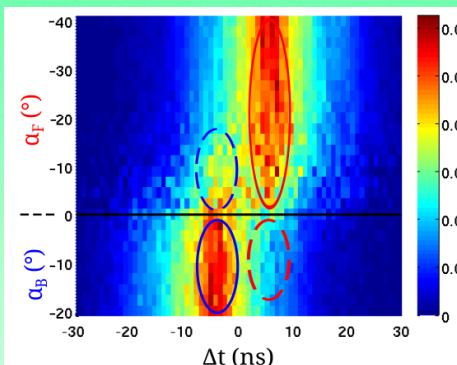


Figure 4. TOF distribution for the SMTOMO data set shown as normalized histograms as a function of zenith angle. The horizon is represented by the dashed line. The blue and red solid ellipses respectively show the backward ( $\alpha_B < 0$  and  $\Delta t < 0$ ) and forward ( $\alpha_F < 0$  and  $\Delta t > 0$ ) events corresponding to the downward fluxes. The dashed ellipses show events corresponding to upward-going muons from forward (red ellipse,  $\alpha_B < 0$  and  $\Delta t > 0$ ) and backward (blue ellipse,  $\alpha_B < 0$  and  $\Delta t < 0$ ).

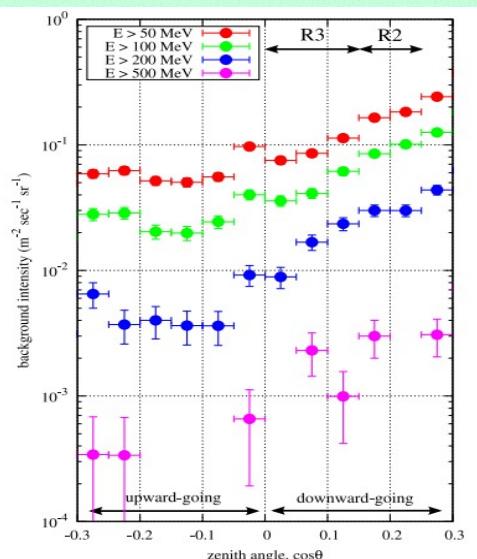
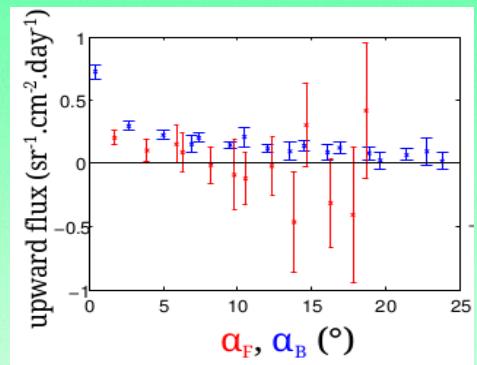
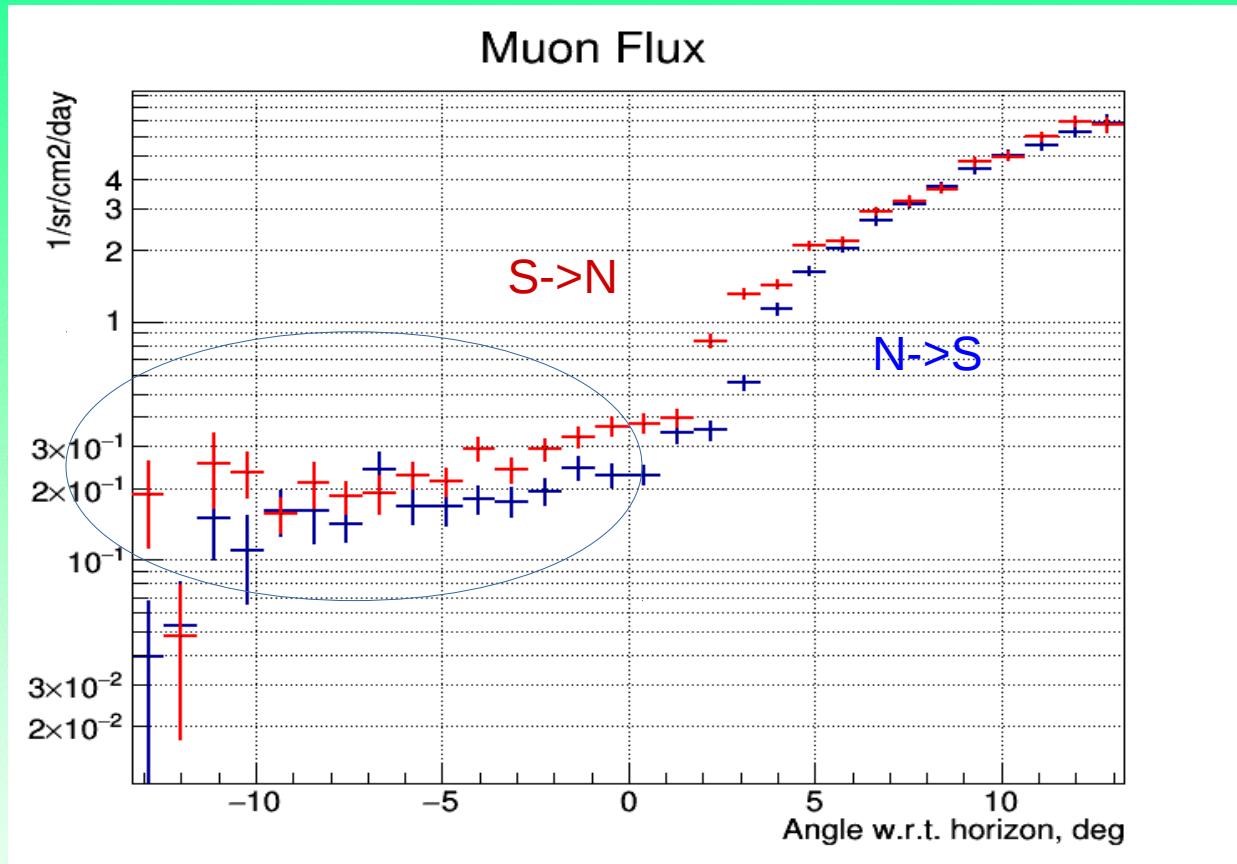


Figure 6. Zenith angle dependence of the calculated flux of the background particles for kinetic energy above 50, 100, 200 and 500 MeV (protons, electrons and muons are added).  $\cos \theta < 0 (> 0)$  indicates downward (upward) going particle.



### Proposal:

measure energy spectrum of particles near (below) horizon with the TPC data.  
(if fast- delta ray count, delta ray spectrum, shower reco; if slow - MCS, dE/dx)  
Clarify “through-going vs scattered” dilemma.